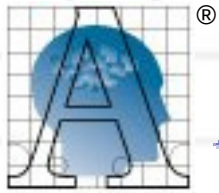
University of South Florida
USF



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Collaborative Critical Thinking

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11 – 13 January 2005

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Agenda

I. Objectives
II. Expected Final Products/Tools being developed
    I. Theory and measures
        I. Theory
        II. Measures
        III. Potential fit/contribution to Knowledge Building or Collaborative Processes
    II. CENTER Tool
    III. Training
III. Experiments conducted and empirical findings
IV. Planned demonstrations/validations of technology developed
V. Publications
VI. Lessons Learned

I. Objectives

- Overall Objective
  - Effective collaboration through improved collaborative critical thinking (CCT)
- Objectives for this year
  - Update / revise / improve
    - CCT tool (CENTER)
    - CCT Training
  - Perform lab-based validation study
    - USF
  - Prepare for and perform Field validation study
    - NWC DDD Lab
  - Prepare for fielding of tool (non DDD)
    - NETWARCOM
    - FORCEnet

II. Final Products

- CCT Theory and Measures
- CCT Collaboration Tool (CENTER)
- CCT Training

Potential impact

- Both process and products
  - Improved collaboration
  - Better team decisions
- Measures of CCT

Applications

- Any distributed, synchronous team working together to find a solution.

In the beginning, there was theory…

- Information age warfare
  - Teams are distributed, ad hoc, multi-disciplinary, mission-critical
  - Teams require coordination & collaboration
    - Manage forces & information
    - Achieve effects
  - Supporting coordination & collaboration requires measurement
- Coordination & collaboration processes can be measured
- Collaboration often involves critical thinking. For individuals, CT…
  - Is found in transcripts of planning
  - Can be trained
  - Improves mission performance in Air Defense scenarios

- Alberts, Garstka, Hayes, and Signori (2001)
- Letsky et al. (2003)

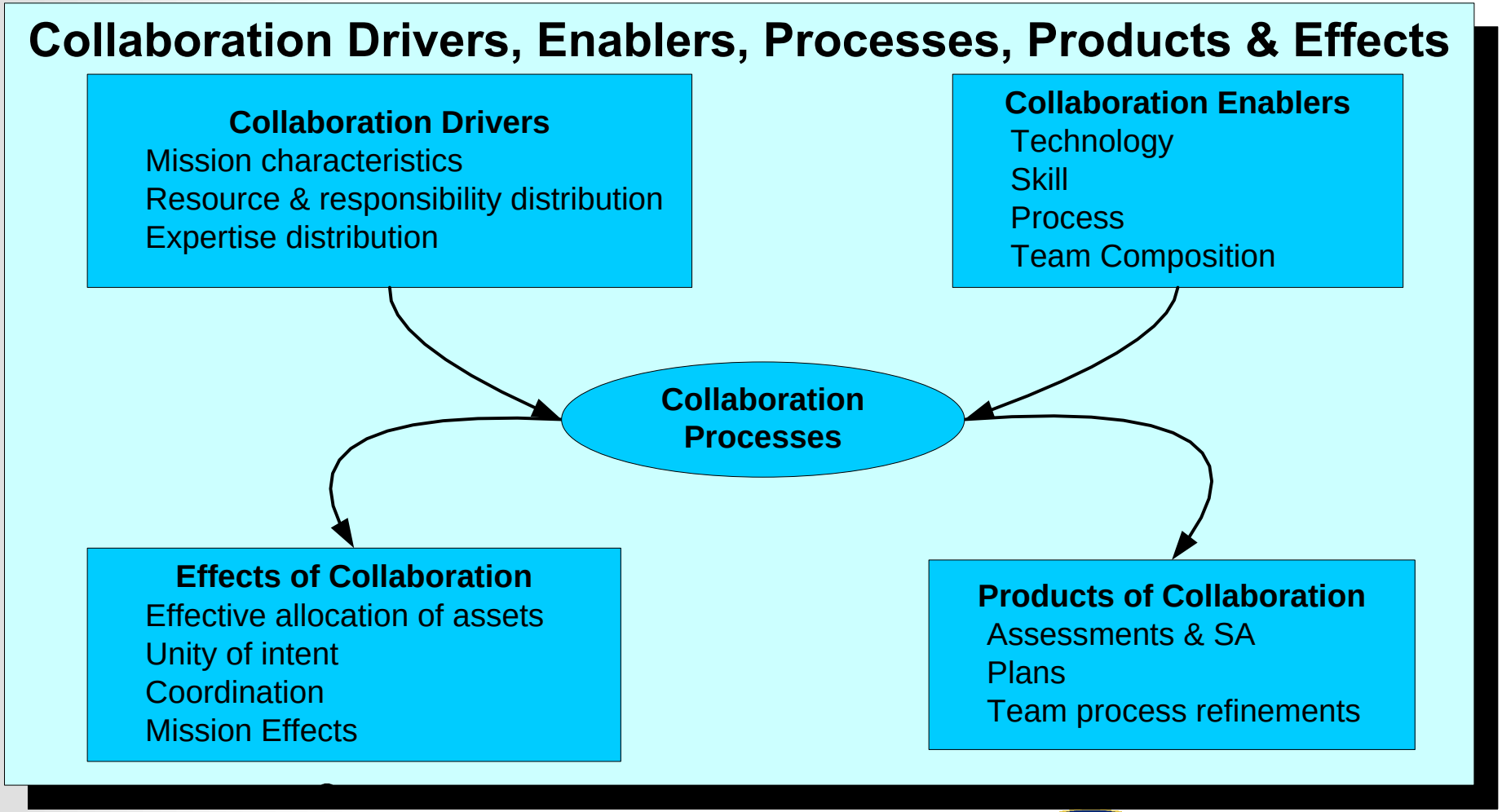
- Macmillan, et al., 2001
- Miller, Price, Entin, & Rubineau, 2001
- Moon, et al., 2000

- Cohen, Freeman, and Thompson, 1998
- Cohen and Freeman, 1997

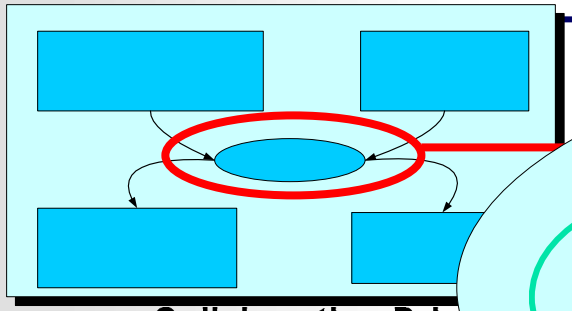
Contribution to collaboration technology

- Expand (individual) critical thinking to (team) collaboration
  - Collaborative critical thinking is teamwork behavior that identifies and reduces uncertainty concerning technical problems and team process.
- Research-based tool
  - Collaboration
  - Team processes
  - Critical thinking
- Tool that is pro-active and prescriptive to improve team collaboration in real-time

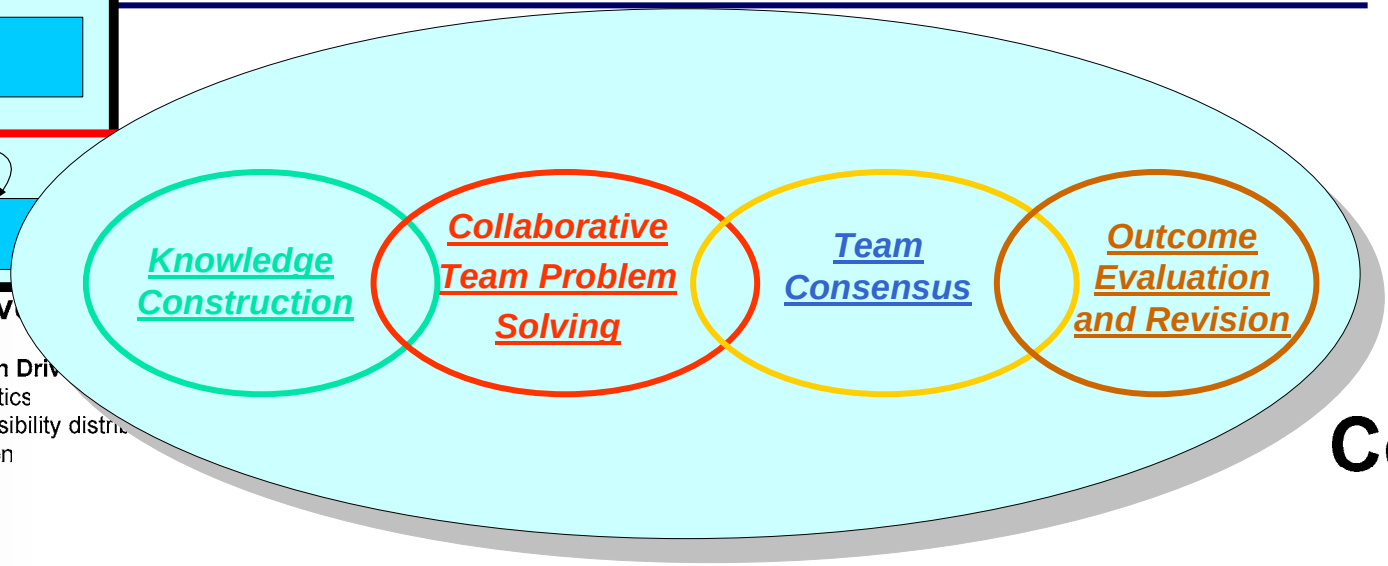
CCT: Theory & Measures (Fit to Collaboration Model)



CCT Theory



Collaboration Driv



Col

Collaboration Driv

- Mission characteristics
- Resource & responsibility distri
- Expertise distribution

Collaboration Processes

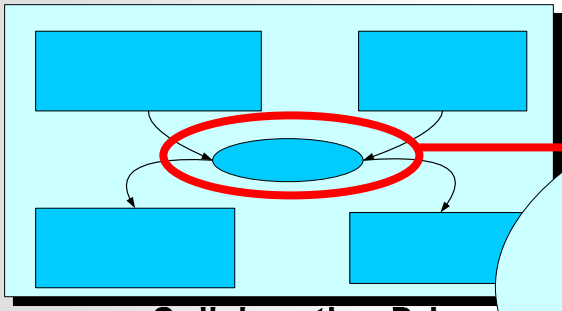
Effects of Collaboration

- Effective allocation of assets
- Unity of intent
- Coordination
- Mission Effects

Products of Collaboration

- Assessments & SA
- Plans
- Team process refinements

CCT Theory



Collaboration Drivers

- Mission characteristics
- Resource & responsibility distributio
- Expertise distribution

Collaboration Stages & Processes

- *Knowledge Construction*
- *Collaborative Team Problem Solving*
- *Team Consensus*
- *Outcome Evaluation and Revision*

Collaboration Processes

Effects of Collaboration

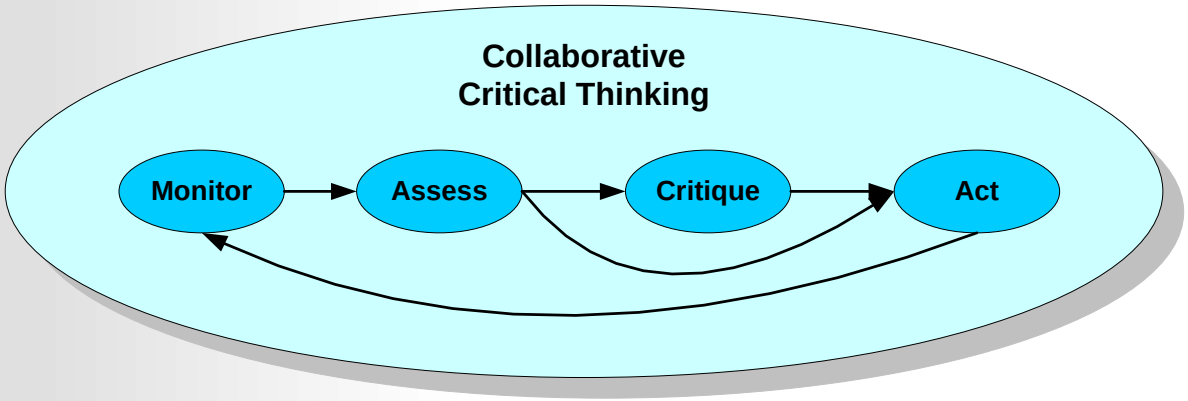
- Effective allocation of assets
- Unity of intent
- Coordination
- Mission Effects

Products of Collaborati

Collaborative Critical Thinking

Monitor → Assess → Critique → Act

A Definition



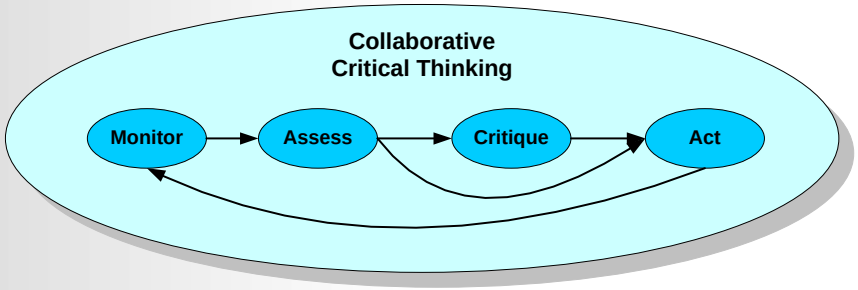
Behaviors

- Collaborative Critical Thinking consists of
  - Interactions[1] to
    - *monitor* for uncertainty,
    - *assess* the risk it presents & the opportunity to address it,
    - conduct *critiques* that identify sources of uncertainty, and
    - devise *actions* that reduce uncertainty & risks or insure against
  - Effects on
    - *the mission* at hand
      - more accurate & precise assessments
      - more effective & robust plans
    - *team processes* for executing that mission

Objects

1. Cohen, Marvin S., Freeman, Jared T. and Wolf, Steve. (1996). *Meta-recognition in time-stressed decision making: Recognizing, critiquing, and correcting.* Journal of the Human Factors and Ergonomics Society.

CCT Behaviors



- *monitoring* interactions
  - that alert other team members to the existence of uncertainty
- *assessment* interactions
  - in which team members evaluate the opportunity (e.g., available time) and need (e.g., priority or stakes) to resolve the uncertainty
- *critiquing* interactions in which team members
  - identify *gaps,*
  - *untested assumptions, &*
  - *conflicting interpretations*
- *actions* reduce uncertainty, at best, or confirm that it cannot be immediately reduced.

CCT Objects

- Team products
  - Assessments
  - Plans
- Team processes
  - Goals – Common intent, Complementary objectives
  - Plans –
    - Task allocation & schedules
    - Asset allocation
  - Tasks – Task execution strategies

Measuring CCT: Objectives

- Help team leaders & team members
  - Monitor for the need to apply CCT to products & processes
  - Assess whether to engage in CCT
  - Critique weaknesses in products & processes
  - Take action to strengthen them
- Assess the effects of CCT on
  - The mission
  - The team

CCT Measures: Products & Processes

	Objects of CCT				
	Team products		Team processes		
CCT Behavior	**Assessment**	**COA/Plan**	**Goals**	**Plans**	**Tasks**
Monitoring	***Measures***				
Assessment					
Critiquing for gaps					
Critiquing for assumptions					
Critiquing for ambiguity					
Action					

- Team members rate status of products & processes wrt CCT behaviors during mission execution
  - Short to minimize distraction from tasks
  - Customized to the mission to enhance relevancy
  - Time sensitive to enhance relevancy
  - Numerically scaled (6=Agree … 1=Disagree, Don't know) to facilitate summarization
  - Optional text comments to deepen meaning
- Present to team leader
  - Aggregated quantitative results
  - Comments
  - Guidance

CCT Measures: Products & Processes

	Objects of CCT				
	Team products		Team processes		
CCT Behavior	**Assessment**	**COA/Plan**	**Goals**	**Plans**	**Tasks**
Monitoring	***A1***				***T1***
Assessment		***C2***			
Critiquing for gaps					***T3***
Critiquing for assumptions				***P4***	
Critiquing for ambiguity					***T5***
Action	***A6***		***G6***		

- A1: The team's assessment [of _____] is correct.
- A6: The team is taking actions to resolve problems with the assessment [concerning _____]
- C2: The team has time to critique and refine the plan [regarding _____]
- P4: The team has identified key assumptions that have yet to be tested concerning its strategy [for _____].
- G6: The actions of team members are consistent with the mission goals [concerning _____].
- T1: Team members seek feedback on their tasks [concerning _____].
- T3: The team is completing all tasks [concerning _____].
- T5: Team members seek to resolve ambiguity in task assignments.

CCT Measures: Feedback

- Probe: ***The team has considered plausible, alternative plans.***
- High agreement (mean rating), little dissent (low variability in ratings)
  - Consider how much effort was expended considering alternative plans.
  - If little effort was expended, team members may be in agreement concerning a hastily generated and incorrect plan. Perhaps team members should expend more effort considering alternative plans. Ask them, “Have you exhausted all plausible alternative plans?”
  - If considerable effort was expended, then ask: “Do you have more time to consider alternative plans?” If yes, then ask: “Are there any plausible, alternative plans that you overlooked?” Probe for lone dissenters and check in with the dissenter.
- Average agreement and lots of variability in responses
  - If little effort was expended, then suggest, “Spend more time working on this task to identify alternative plans.”
  - If considerable effort has been expended, ask, “Do you have more time to consider alternative plans?” If yes, then team members should expend more effort to consider plausible alternative plans

CCT Measures: Effects

Mnemonic	Measure	Example
Who	The fit of team members to mission tasks	Team optimization (Levchuk, et al., 1997-2003)
What	Situational awareness	Situation reconstruction (Endsley & Garland, 2000); Relational knowledge (Cooke, et al., 2000)
Where	Coordination in space	n.a.
When	Synchronization	Asset synchronization (Stacy, Freeman, et al., 2005; Levchuk, et al., 1997-2003)
Why	Unity of intent	tbd…(Aptima, Cooke)
How	The fit of tactics (tasks) to objectives: simplicity, power, observability, vulnerability	Power appropriateness (Levchuk, et al., 1997-2003); tbd

CCT Technology: CENTER
Collaboration for ENhanced TEam Reasoning

Team leader/ facilitator

Probes re:
problem
& process

Ratings &
Comments

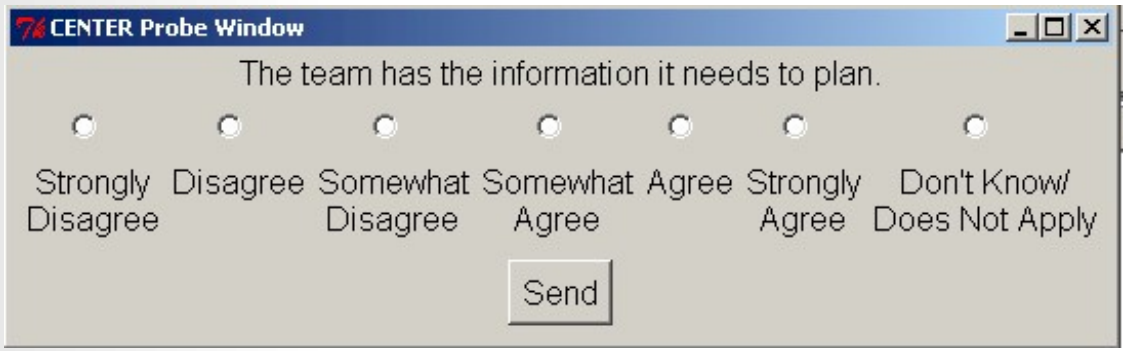
Distributed team members

CENTER
for a Team Facilitator or a Leader's Aid

- Facilitator configures CENTER: Customize CENTER questions to the mission at hand:
  - Problem: **Is there a plausible assessment of** *enemy intent* **that the team has not considered?**
  - Process: **Are your team members appropriately tasked to** *complete the assessment in two hours?*
- CENTER automatically queries team members

CENTER for Team Members

- CENTER pops a question in small "probe" window atop current application.
- Member
  - Responds with rating
  - Optionally comments



CENTER
for a Team Facilitator or a Leader's Aid

- CENTER compiles team members' responses
- CENTER presents facilitator with
  - Summary of ratings for at-a-glance assessment of team
  - Comments by members
  - Suggested actions
- Facilitator adjusts the team's course

"Synergistic" Technology

- There are distributed collaboration platforms available
  - Infrastructure from many vendors, for example
    - Microsoft (Sharepoint)
    - IBM (Lotus Notes)
    - Groove Networks
    - Sitescape
  - The infrastructure targets convenience and speed in collaboration.
- The CENTER tool
  - Operates "on top of" existing infrastructure.
  - Supplements those offerings by targeting the quality of collaboration.

Benefits

- Collaboration tools (email, telecons, Word versioning) help create products
  - CENTER helps team evaluate products & process
- Training helps teams learn new processes
  - CENTER ensures they use new processes
- Group decision-ware (voting tools) replace standard tools
  - CENTER complements standard tools

- CENTER
  - Python programming language.
    - An interpreted, interactive, object-oriented programming language
    - Comparable to TCL, Perl, Scheme, or Java.
    - Can run in any operating system.
  - The CCT tool has a client/server architecture and uses MySQL for the back-end database.
  - The tool is designed to run over the Internet.
  - The users of the tool do not have to be using the same operating system when the tool is running.
    - i.e some users can be in Windows and some can be in Linux and still communicate and pass information seamlessly.

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Current state and future vision: Center Tool

	Designed and implemented	Designed and yet to be implemented	To be designed and implemented
Participant	Unobtrusive pop-up window		
	Radio buttons with anchors for rating		
	Questions are on a timer; they blank out and the window minimizes when time is up	Instead of blanking out, the window will say “waiting for the next probe”	There will be a count down until the window closes
	Comment capability (currently “commented out”)		
Facilitator / Authoring	Click and send probes	“Auto send” probes based on timer	
	Real-time results from probe	Feedback based on participant’s responses to probes	Ability to review meeting with screen shots by specifying time period
	Real-time probe authoring		Create authoring mode
		“Roll over” graph labels	
			Probe organization scheme with more probes “in storage”
Other	Linux installation package	Windows executable installation package	
		Test plan (begin with fictitious (i.e., programmed) participants; then do with real people)	
	Capabilities for spatially distributed team		Truly asynchronous capabilities (separation in time and space)

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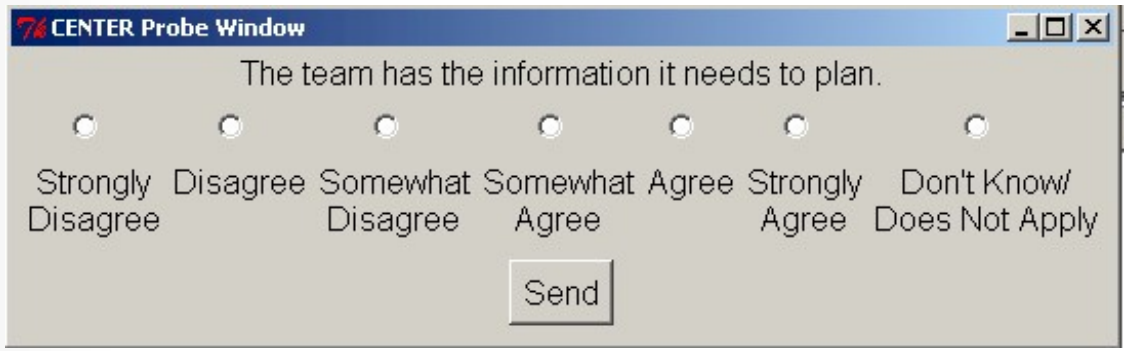

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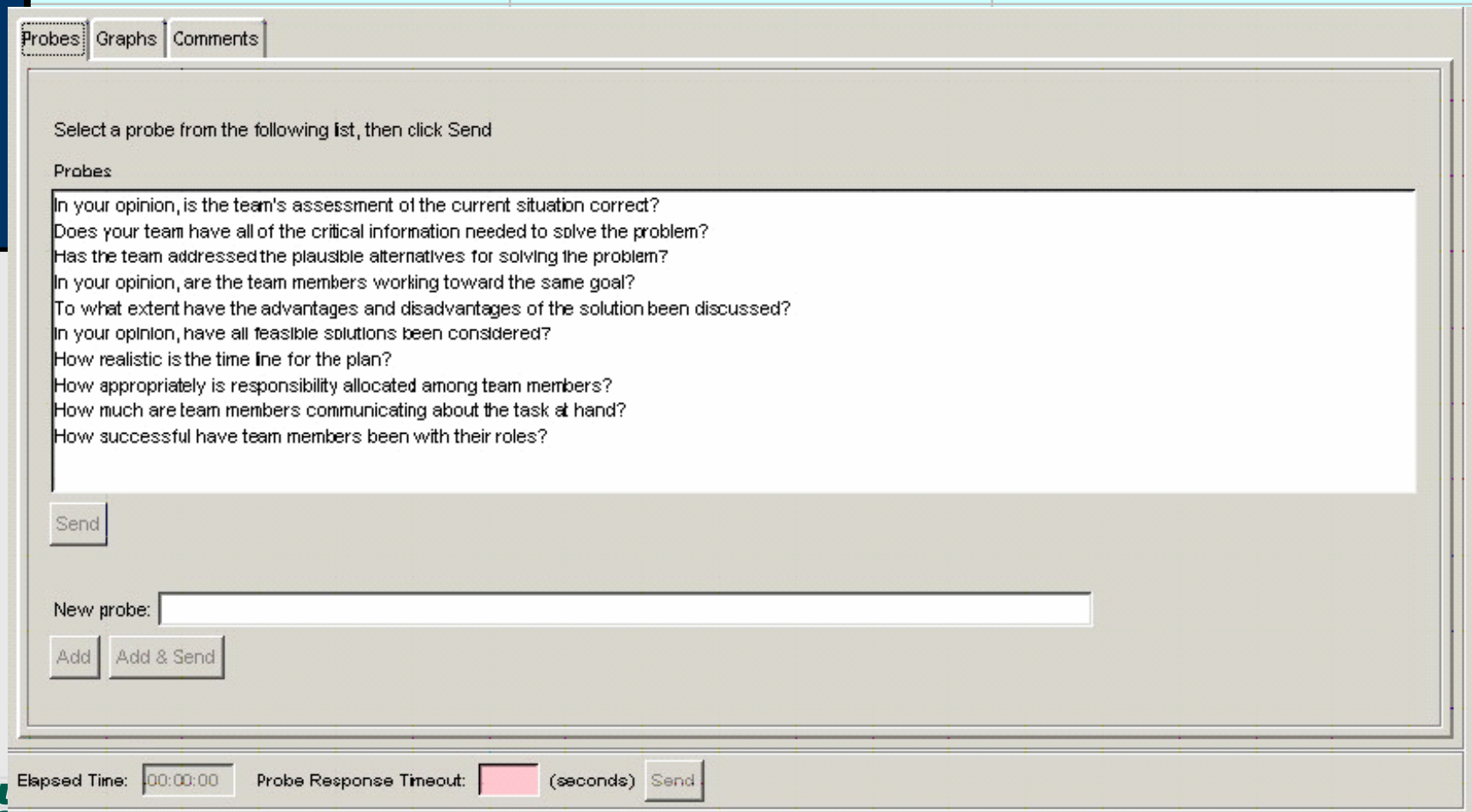

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	Designed and implemented	Designed and yet to be implemented	To be designed and implemented
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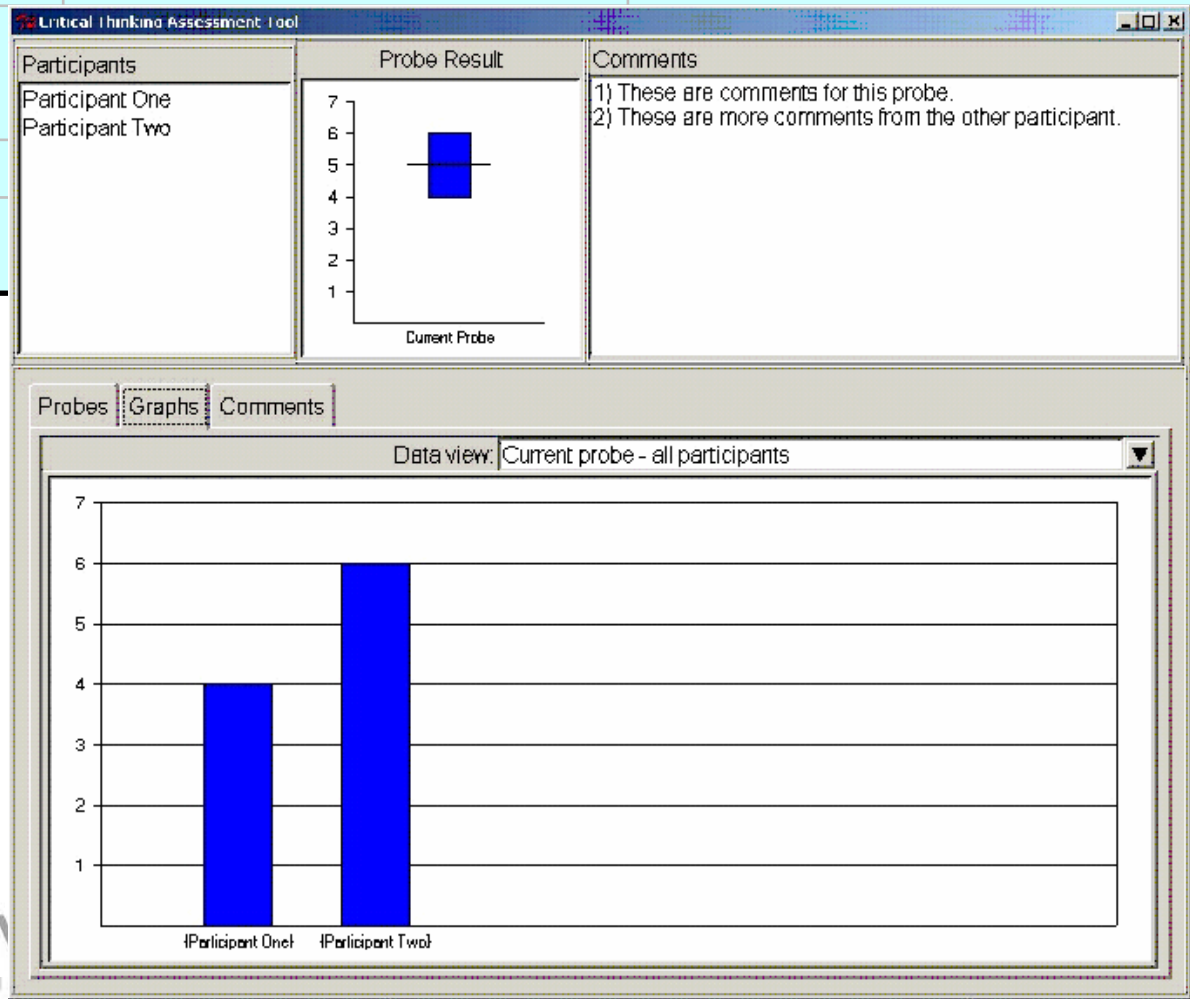

Current state and future vision: Center Tool

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		"Roll over" graph labels	
			Probe organization scheme with more probes "in storage"

Probe: The team has the information it needs to plan.

Analyses reveal: Mean is average and Variance is high

Feedback to facilitator: If lots of time has been spent, seek to understand why there is so little consensus. Perhaps team members need to revisit prior decisions and then revisit the current problem. Ask, do you understand the information?

Current state and future vision: Center Tool

	Designed and implemented	Designed and yet to be implemented	To be designed and implemented
Facilitator / Authoring	Click and send probes	"Auto send" probes based on timer	
	Real-time probe authoring		Create authoring mode
	Real-time results from probe	Feedback based on participant's responses to probes	Ability to review meeting with screen shots by specifying time period
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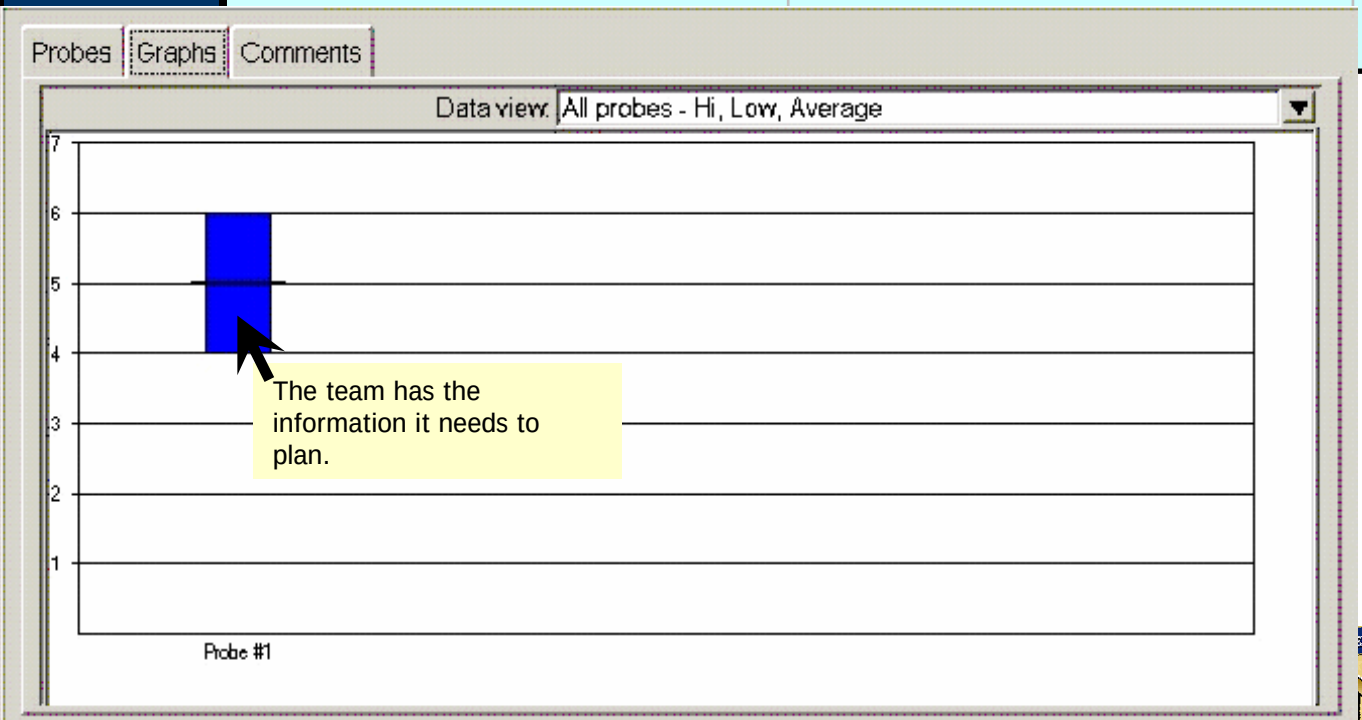

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	Designed and implemented	Designed and yet to be implemented	To be designed and implemented
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		Test plan (begin with fictitious (i.e., programmed) participants; then do with real people)	
	Capabilities for spatially distributed team		Truly asynchronous capabilities (separation in time and space)

Current state and future vision: Training and Validation

	Completed	Designed and in progress	To be designed (option task)
Development	Studies to better understand CCT		
	Study to investigate possible cognitive and affective components of CCT for training development		
	CCT training and facilitator training	Improve CCT training based on results of experiment	Improve CCT training to make more appropriate for military / expert teams
Usability	Usability studies with pop-up window		
	Initial usability studies with facilitator window		
Lab Validation	Study to validate CCT probes		
	Initial validation evidence for training	Initial validation evidence for tool	
Field validation and use			Field validity evidence (Option task)
			Use in field setting

III. Experiments

- Completed Studies
  - Studies to better understand CCT
    - We were able to get examples of CCT to guide definition and framework development
  - Studies to test possible impact of cognition and affect to guide training development
    - Neither the cognitive nor the affective training made an impact in CCT performance; thus, they were not included in the training
  - Usability studies
    - Guided improvements to the user pop-up window and the facilitator workspace
  - Initial study to validate critical thinking probes
    - Probes were at the correct level for the target population
    - Participants felt that probes helped them execute planning tasks
  - Validation Study at USF
    - Behaviorally-based CCT training resulted in improved task performance

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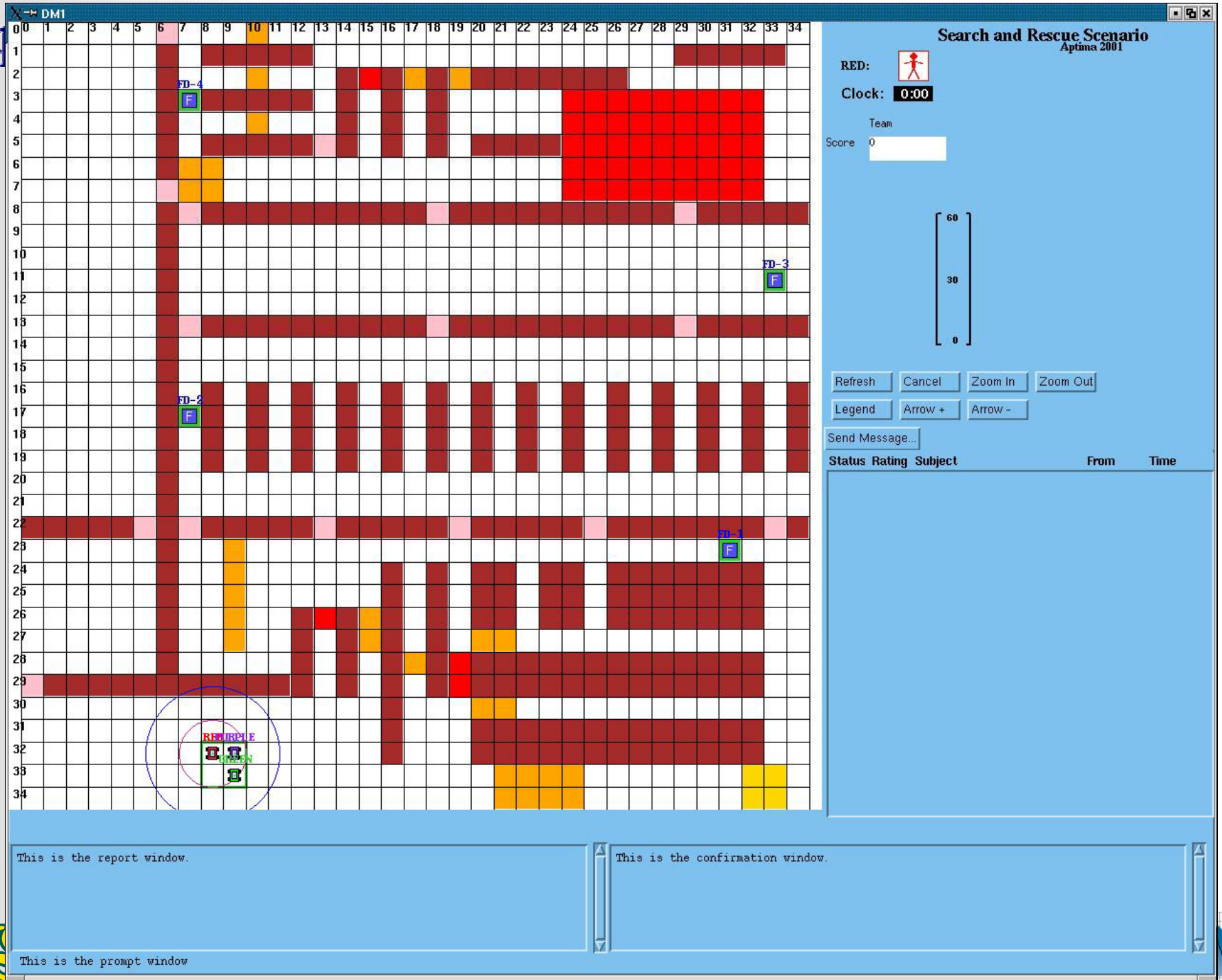
Most Recent Experiment

- Still on-going at USF
- Objective:
  - Collect validity evidence for CENTER tool and training
- Method:
  - Each of 2 team mem
    - No training
    - CCT Training
    - Or control train
  - Teams plan for com
    - With CENTER tool
    - Or not
  - Teams execute Sear

- Content
  - Content
    - Basic Steps to Survival
      - S – Size up the Situation
      - U – Use all Your Senses, Undue Haste Makes Waste
      - R – Remember Where You Are
      - V – Vanguish Fear and Panic
      - I – Improvise
      - V – Value Living
      - A – Act Like the Natives
      - L – Live by Your Wits, but for Now, Learn Basic Skills
- F
ta
- Process ("hands-on" task)
- (
- Content
  - Ensure shared understanding of the basic steps to survival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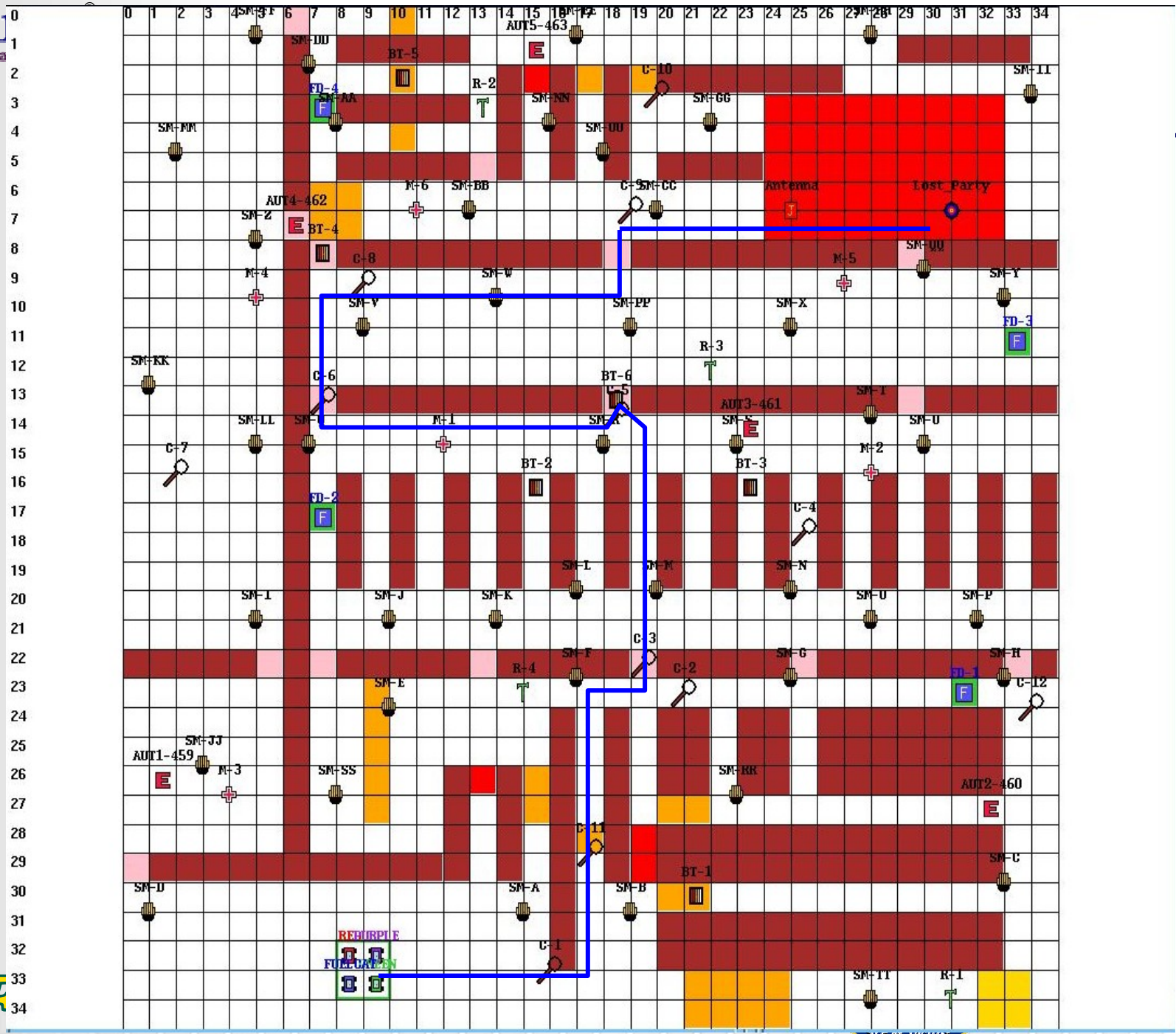
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SM-AA
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SM-MM
SM-OO
Antenna
Lost Party
M-6
SM-BB
C-9
SM-CC
AUT4-462
SM-Z
BT-4
C-8
SM-QQ
M-5
M-4
SM-W
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SM-V
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REHURPLE
C-1
SM-TT
R-1

Approach

- Experimental Design:
  - 5 conditions

Conditions	No CCT probes	CCT probes
No training	X	
Survival training (control)	X	X
CCT training	X	X

  - Performance measures collected through the DDD

Analyses

- Measures
  - Used by tool to gauge CCT
    - Probes
      - Analyses done in real time
  - Used to validate CCT training
    - DDD Performance
      - Number of clues / UGS processed correctly
      - Time to find lost party / antenna
    - Debrief Questions
      - Did the probes make you think differently about the problems or how the team needed to perform?
      - How influential were the probes in your thinking?
- Analyses
  - Evaluate impact of training
  - Test hypothesis that teams participating in CCT training perform better on the DDD
  - Hierarchical analyses to investigate contributions of individual characteristics

Findings*

- Both CCT Training and the Survival training improved the team performance over no training
- The effects of the CCT Training and the Survival training on performance was statistically the same.
  - Two different methods to increase team performance
    - One focused more on critical thinking and context free decision making
    - One focused on decision making in a naturalistic environment similar to the actual task environment
- Some individual differences traits are relevant to the group dynamic:
  - CCT is enhanced with
    - Increasing agreeableness of team members
    - Increasing assertiveness of team members,
    - IQ

*Note: CENTER tool validity is in the process of being tested

IV. Future Validation

- USF CENTER Tool validation
  - Teams plan for DDD computer simulation
    - With CENTER tool
    - Or not
- Field
  - Field validation study
    - NWC DDD Lab
  - Non-DDD fielding of tool
    - NETWARCOM
    - FORCEnet

V. Publications planned, technical contributions

- Society for Industrial and Organizational Psychologists 2005 Academic Practitioner Forum
- Freeman, J. and Hess, K. (2003). Collaborative critical thinking. Proceedings of the 8th International Command and Control Research and Technology Symposium. Washington, DC.
- Freeman, J. and Serfaty, J. (2002). Team critical thinking. Proceedings of the 7th International Command and Control Research and Technology Symposium. Monterey, CA.

VI. Lessons Learned

- When working with others you take the good with the bad
- Sometimes participants learn from the “control” training
- Nothing ever goes the way it is planned.

Project Summary

- Title: Collaborative Critical Thinking (CCT)
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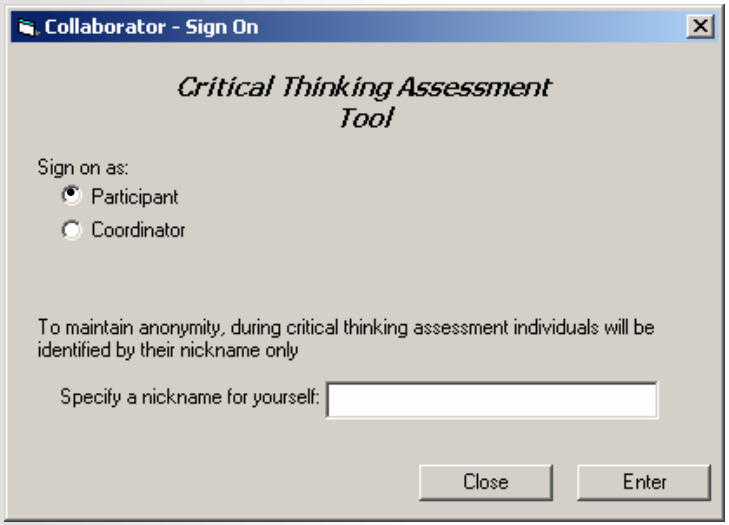
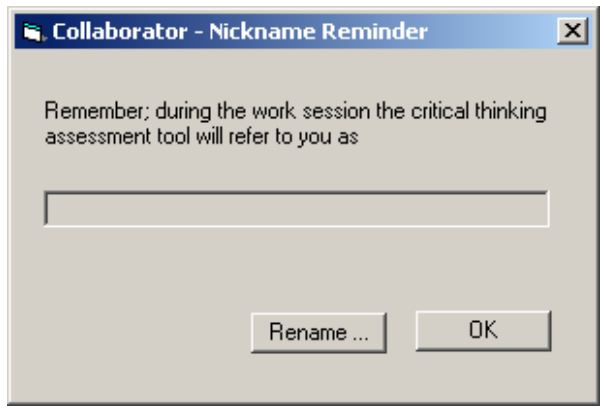
- Objectives
  - Better understand CCT
  - Develop validated training and tools to improve CCT
  - Improve the process and products of collaboration through improved CCT
- Research Questions
  - Can CCT behaviors and their effects be reliably measured in a semi- or fully-automated fashion?
  - Can we promote CCT behaviors with training and job aids?
  - Does improved CCT result in improved collaboration?
  - Can we field the CENTER tool?
- Project Status
  - Initial validation studies have been run
  - Tool and training are being revised based on the study results
  - Field validation studies are being planned

Supplemental Material

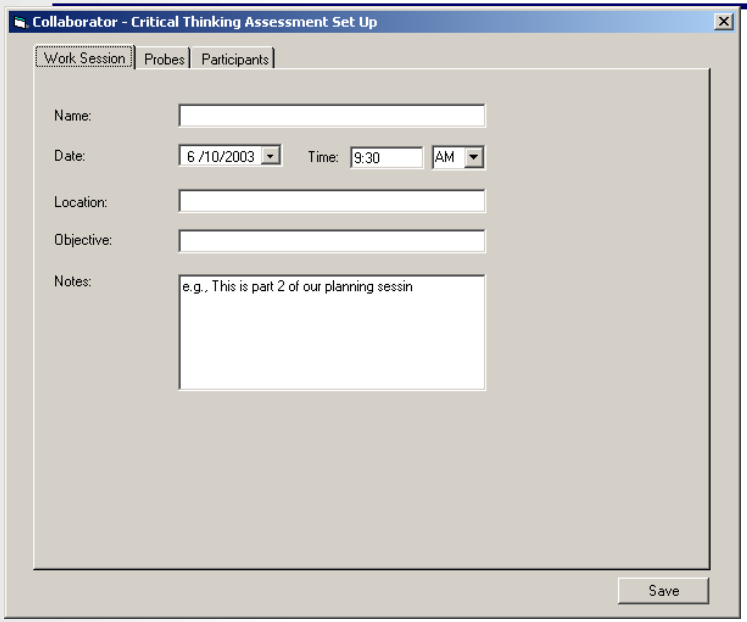
Sign on dialog

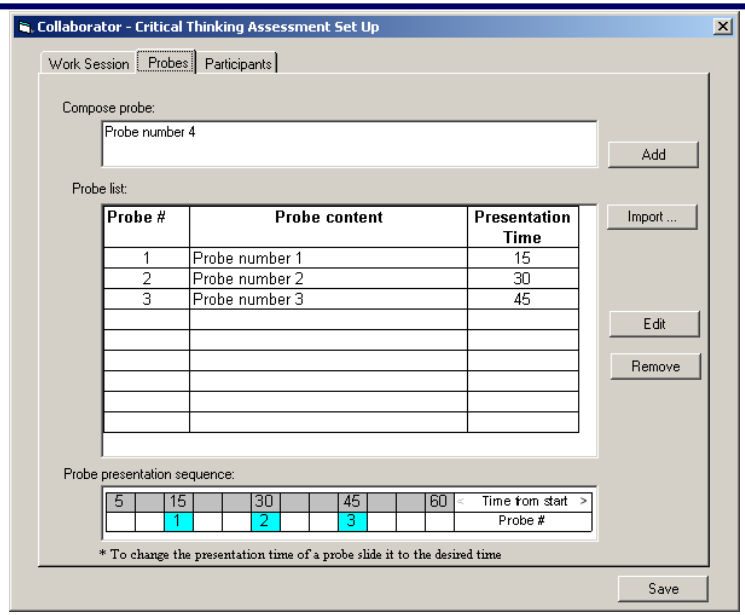


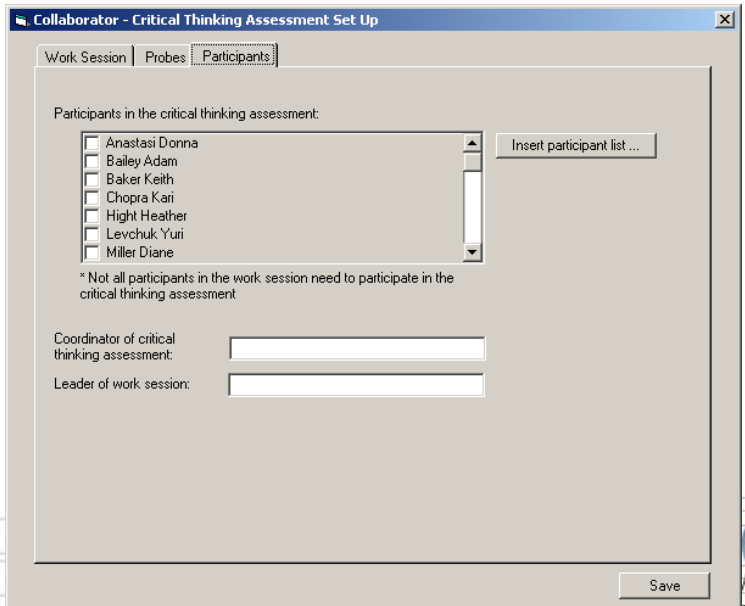
Note; When signing on to the CCT Tool the participants are already logged onto the collaborative application.



Coordinator's Configuration Interfaces

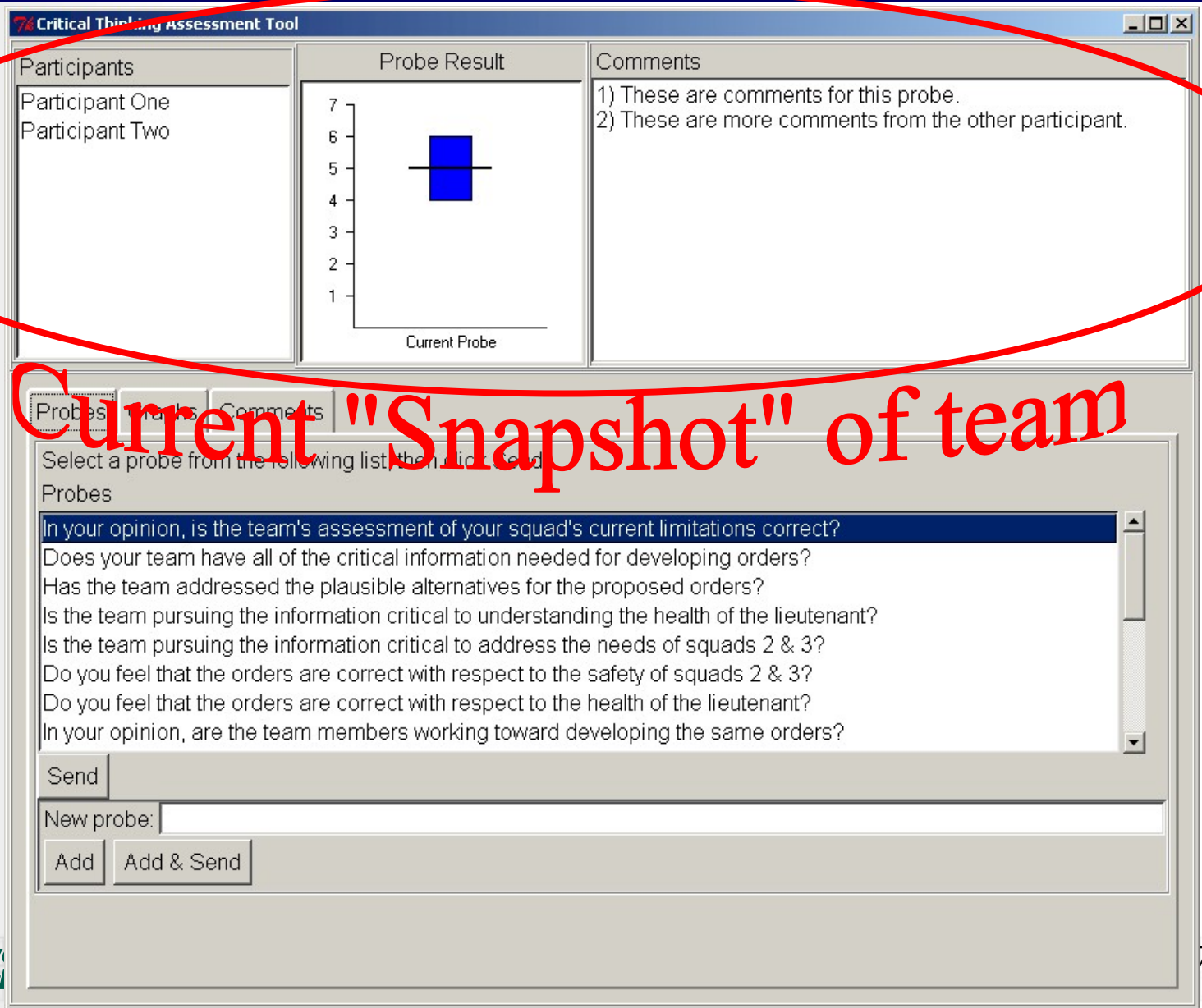






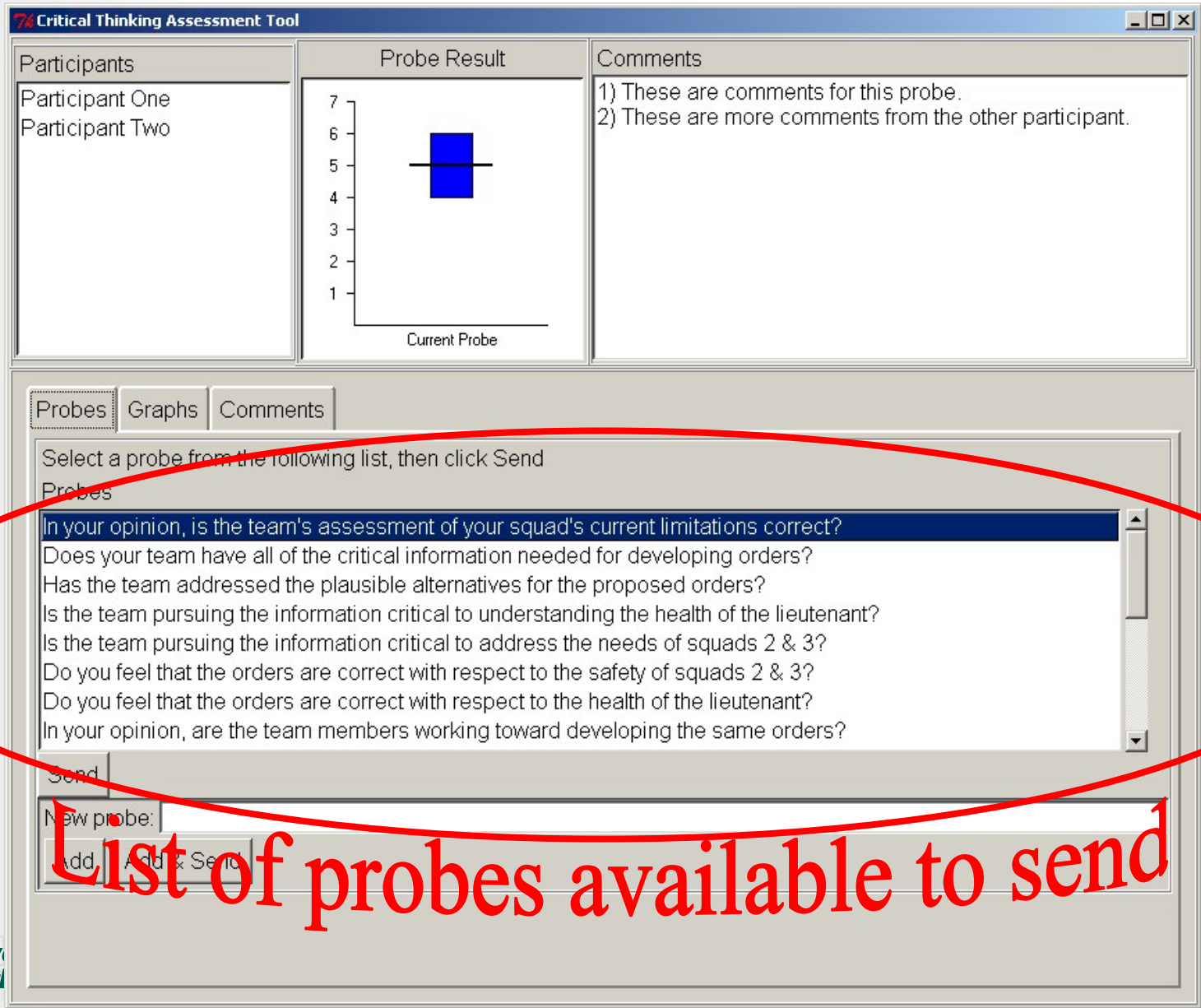
- Configure (clockwise)
  - Work session
  - Probes & schedule
  - Participants

Facilitator Screenshot



Current "Snapshot" of team

Facilitator Screenshot



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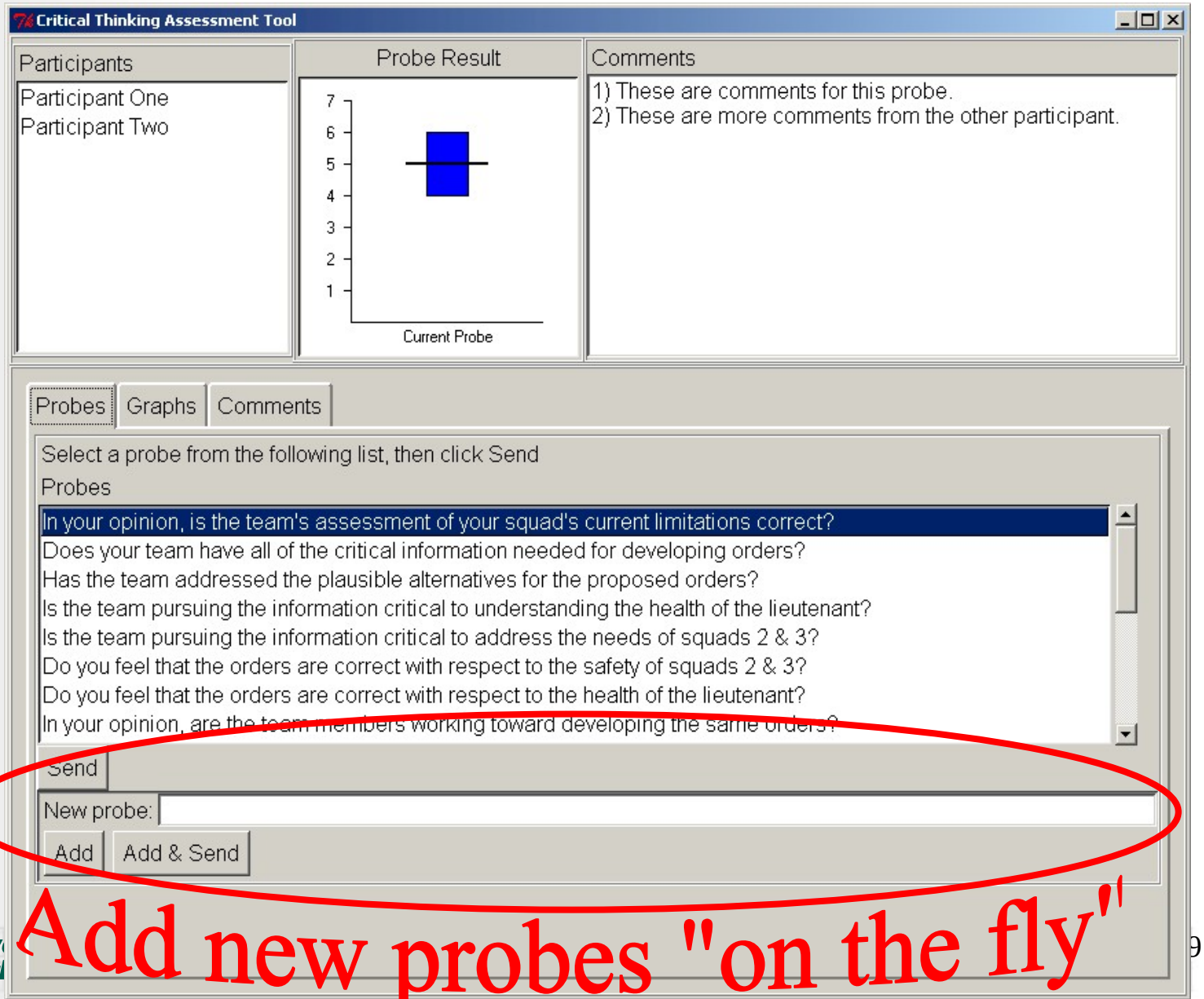
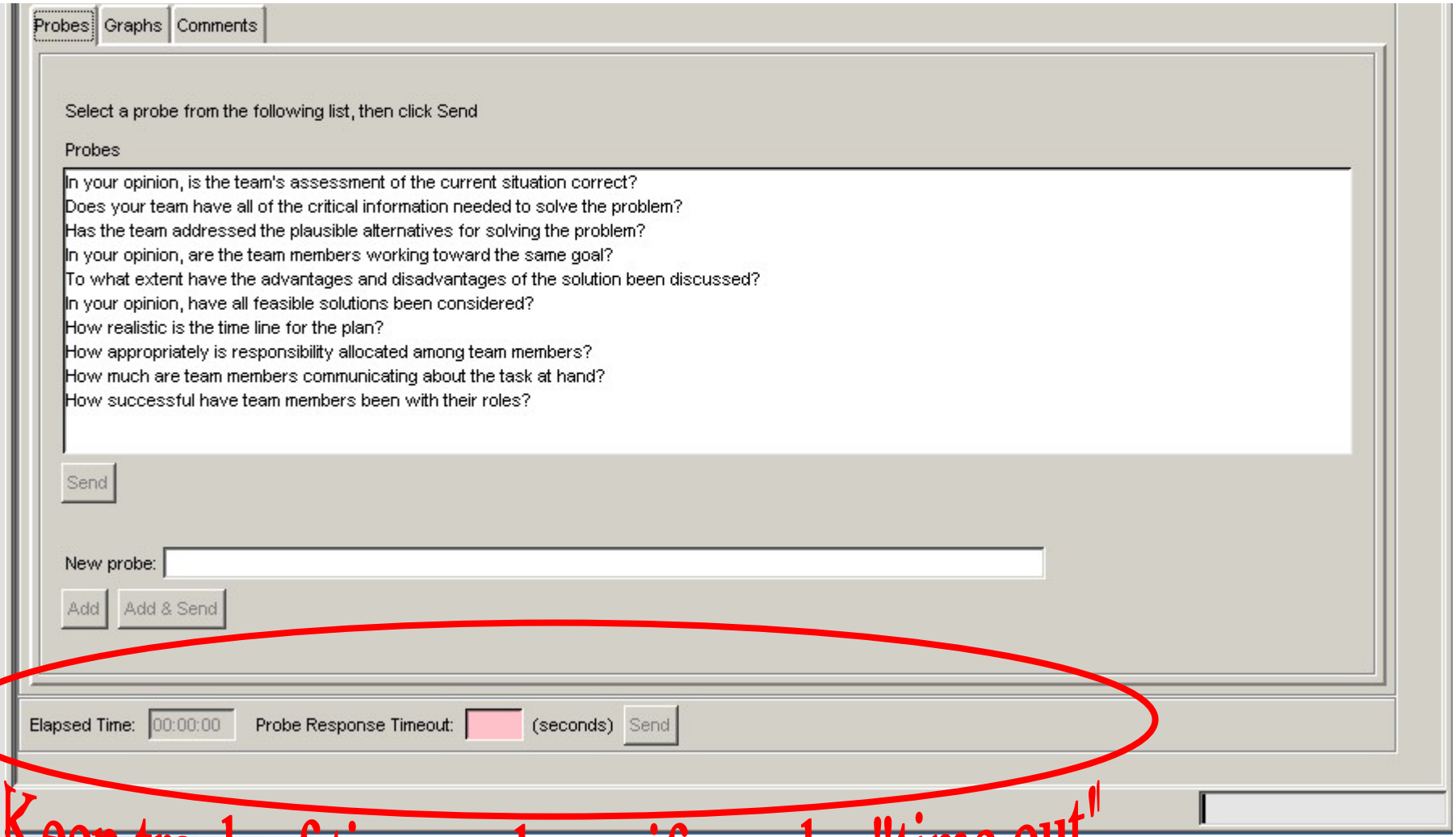
Facilitator Screenshot



Add new probes "on the fly"

Facilitator Screenshot



Keep track of time and specify probe "time out"

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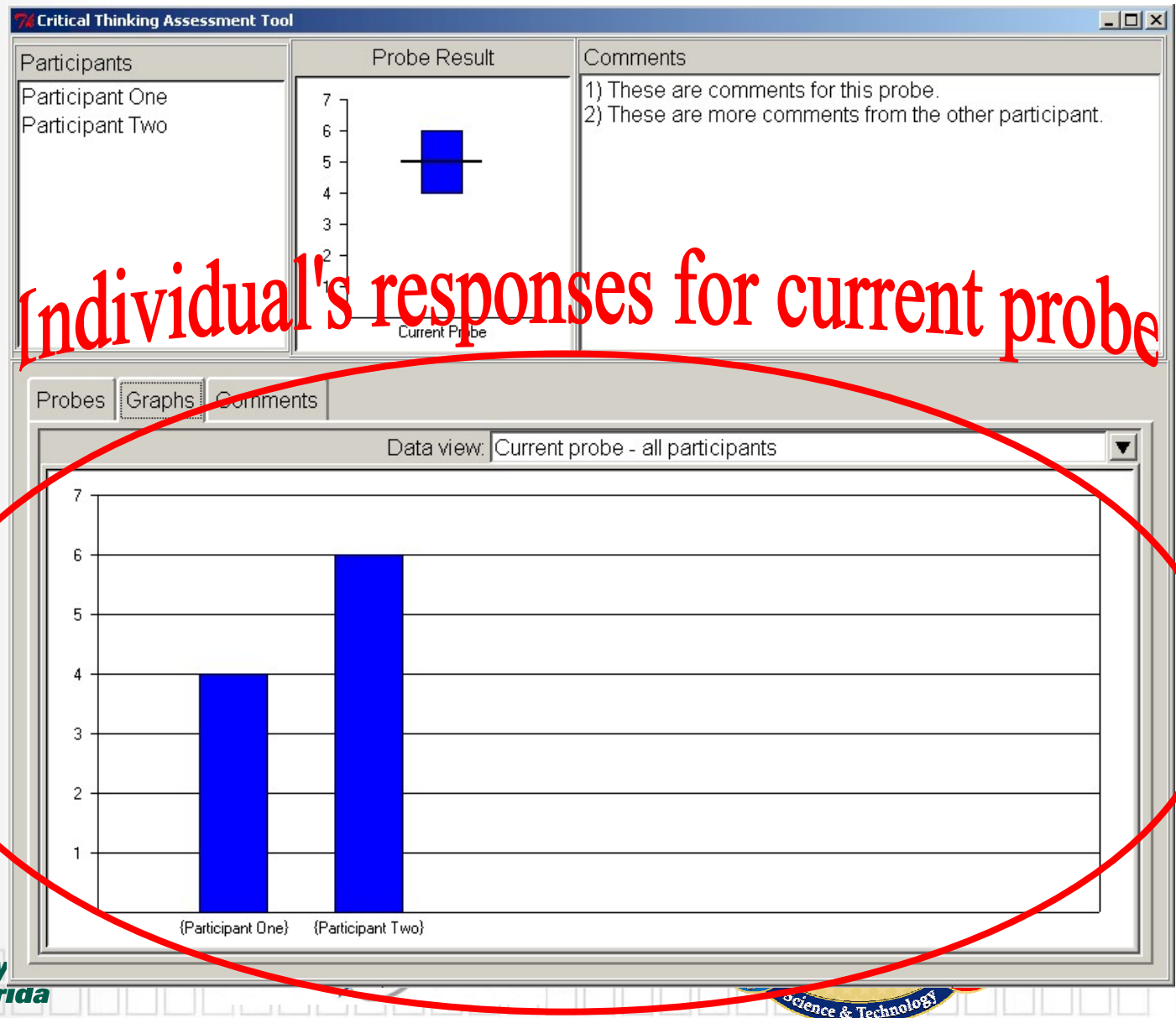
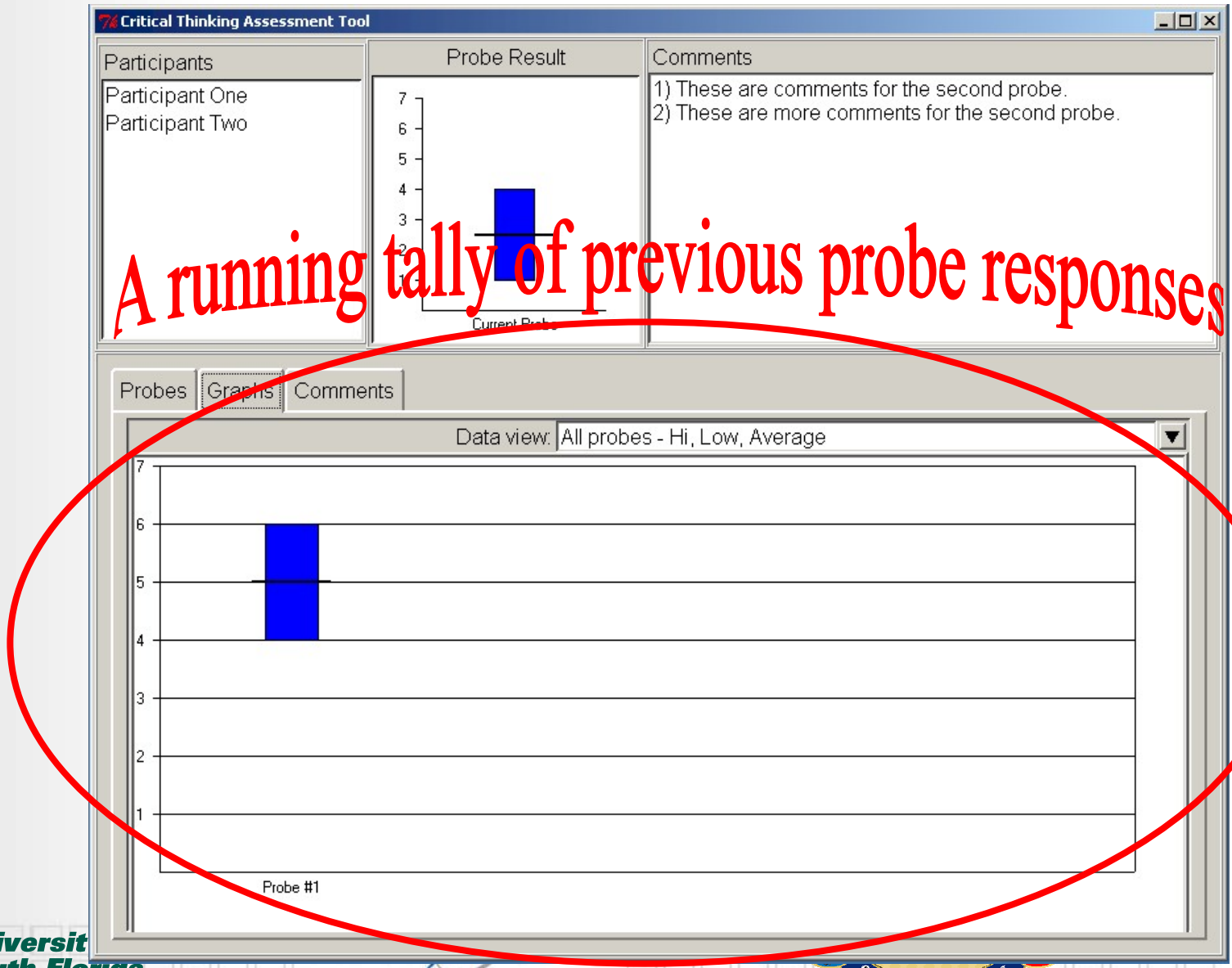
Facilitator Screenshot



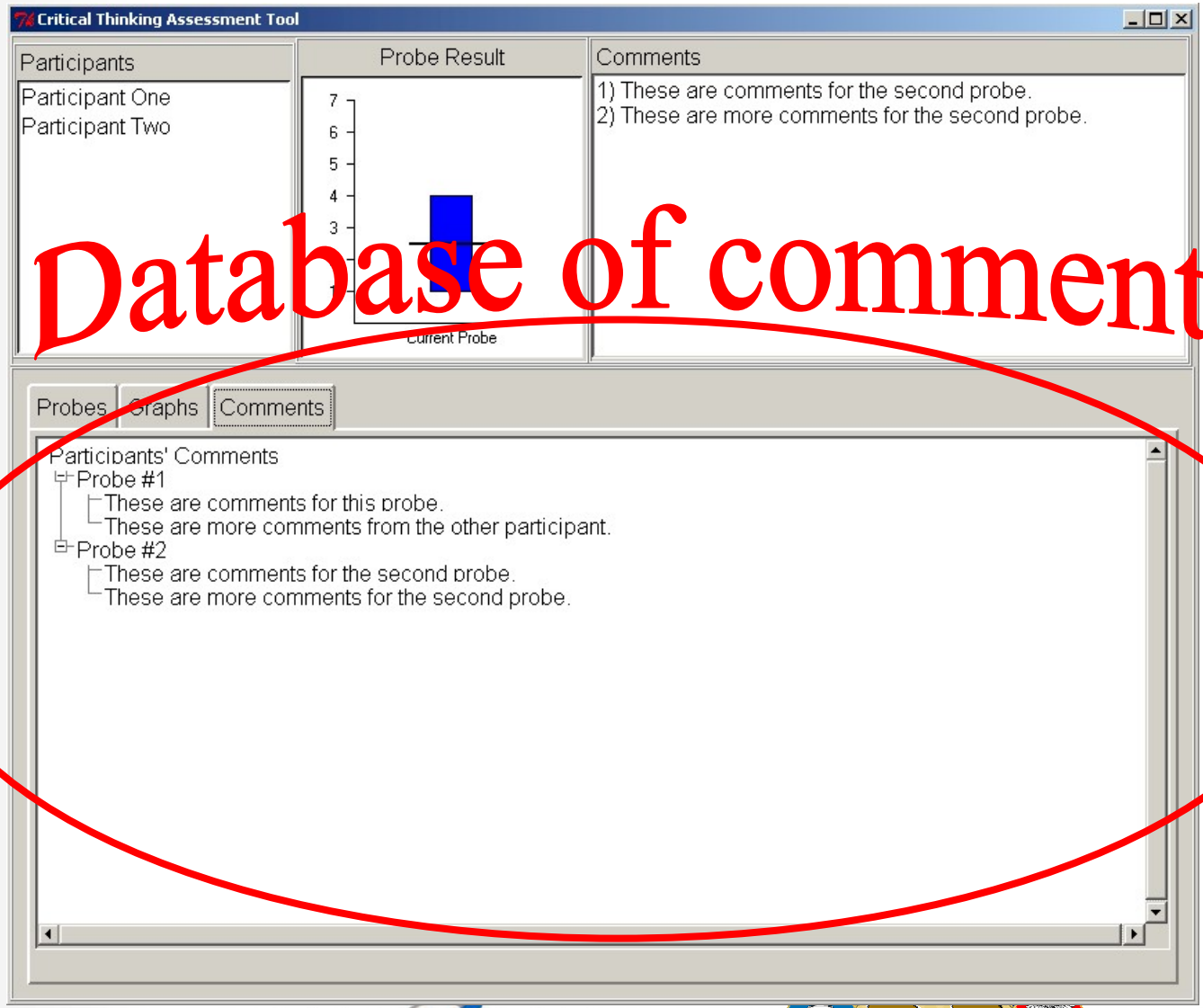
USF University South Florida

Science & Technology

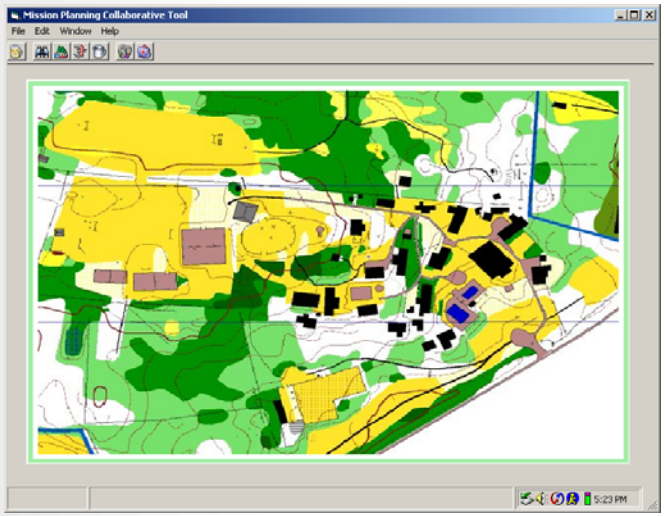
Facilitator Screenshot

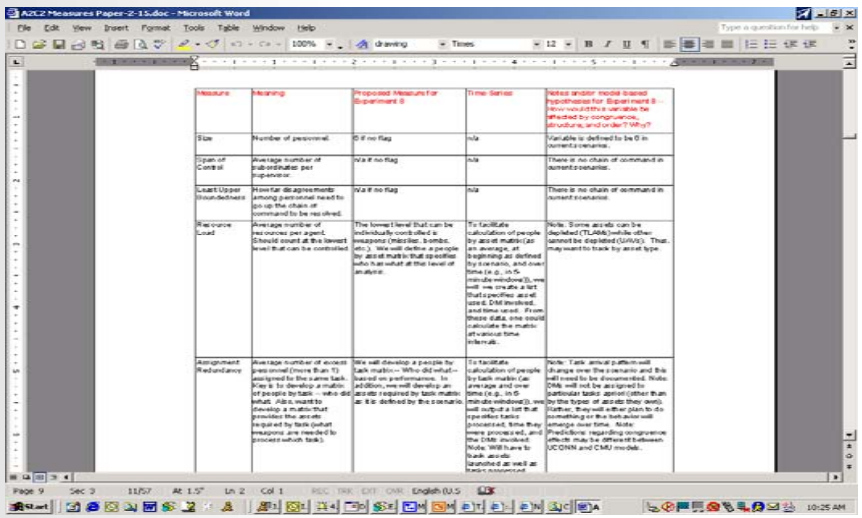


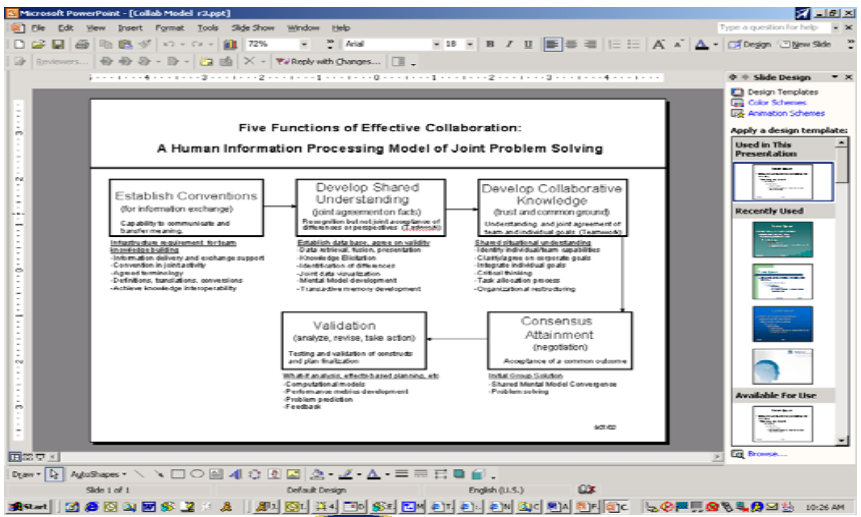
Facilitator Screenshot



Workspaces in a Distributed Team







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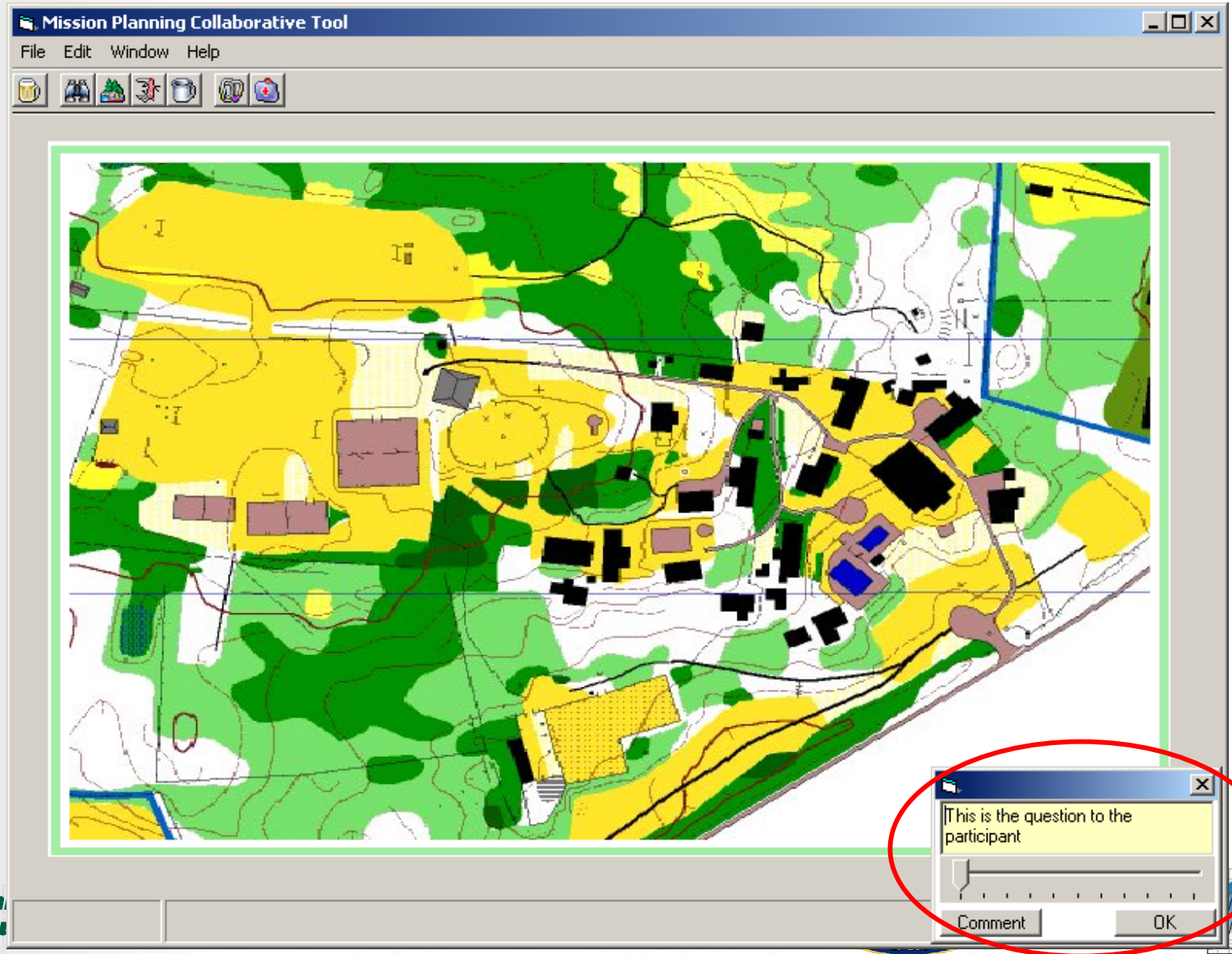
Team Member Screenshot



Opportunity to Rate and Comment